PERISTALTIC FLUID PUMP

RIGHTS OF GOVERNMENT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to peristaltic pumps adapted for use in causing fluids to be advanced through a flexible tube in a predetermined manner. Such equipment is widely used in producing and evaluating or analyzing fluids in pathological, medicinal, surgical, chemical, and industrial fields. For these purposes, flexible tubes are compressed progressively at successive points longitudinally thereof to force the fluid along the tube in a predetermined direction. The amount of the fluid pumped through the tube is dependent upon the cross-sectional area of the tube and the rate at which the successive portions of the tube are compressed. Thus, the amount of fluid pumped through the tube can be varied by changing the size of the tube or by varying the speed at which the tube compressing means are moved along the tube.

2. Description of the Prior Art

It has been usual heretofore to provide peristaltic pumps wherein rollers move cyclically over a length of resilent tubing to cause a progressive localized flattening of the tube to propel the liquid therethrough ahead of the constriction, and to provide a reduced pressure behind the constriction to introduce more fluid into the tubing for propulsion by the next following roller. Another form of peristaltic pump is one wherein the flexible pumping tube, provided with inlet and outlet check valves, is surrounded by a hydraulic fluid which is subjected to a variable pressure to cause the flexible tubing to alternately collapse and expand to respectively expel the fluid therein and receive new fluid.

While such pumps are widely used, they present certain serious problems in that the mechanical rollers or hydraulic valves utilized as a motive force for the pumped fluid are subject to deterioration and are prone to mechanical failure. Such hydraulic and mechanical systems also add substantially to the complexity and cost of the peristaltic pump. Additionally, the pumping of body fluids, particularly blood, imposes severe restrictions on the design of a pump intended for this purpose. Not only must the sterility of the blood be preserved, but also the blood must not be subjected to excessive mechanical forces that would cause the blood cells to rupture.

Accordingly, it is the primary object of the present invention to provide a peristaltic pump of general utility that while simple in construction and with a minimum of moving parts is capable of effectively moving fluids.

Another object of the present invention is to provide a peristaltic pump that obviates the need for mechanical rollers or hydraulic valves as motive forces for the pumped fluid.

A further object of the present invention is to provide an improved peristaltic pump that pumps blood or other cellular fluid gently by eliminating the need for valving and mechanical operations to prevent regurgitation, turbulance and stagnation of the fluid.

Still a further object is to provide a peristaltic pump which is controlled by simple electrical apparatus from which the pumped fluid can be synchronized in both magnitude and velocity to match some external and environmental condition.

It is the specific object of this invention to provide a peristaltic pump that utilizes the unique properties of a ferromagnetic fluid as a motive force for the pumped fluid.

SUMMARY OF THE INVENTION

Briefly, in accordance with the invention, a peristaltic pump is provided in which a continuous flexible tube is surrounded by a chamber that contains a ferromagnetic fluid to be utilized as the motive force for the pumped fluid within the flexible tube. A plurality of electrically conducting wires are circumferentially located in the form of loops around the periphery of the flexible tube at selected intervals along its length in close proximity to the ferromagnetic fluid. When a current is passed through such a loop it establishes a magnetic force within the surrounding ferromagnetic fluid. The strategic location of the conducting loops with respect to the ferromagnetic fluid and the flexible tube allows said magnetic force to be utilized to flex the flexible tube in a predetermined manner to provide a motive force for the fluid within the tube. The sequential application of current to the conducting loops along the length of the flexible tube causes the tube to flex progressively from its inlet to its outlet to thus propel the fluid contained therein.

BRIEF DESCRIPTION OF THE DRAWINGS

The specific nature of the invention as well as other objects, aspects, uses, and advantages thereof will clearly appear from the following description and from the accompanying drawings, in which:

FIG. **1** is a sectional side view of a peristaltic pump embodying the present invention;

FIG. **2** is a sectional side view illustrating one embodiment of the present invention; and

FIG. **3** is a sectional side view illustrating another embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The basic principle of the invention is illustrated in a hybrid embodiment in FIG. **1**. A tube **18** is formed of a flexible material and provided with an inlet end **10** and an outlet end **11** adapted respectively to be connected to a suitable source of the fluid to be pumped through tube **18** and to a mixing or other device or chamber to which the fluid is to be supplied. Alternatively, inlet end **10** and outlet end **11** may be connected to additional sections of flexible tubing similar to that shown in FIG. **1** to provide a continuous path for the fluid to be pumped.

Surrounding flexible tube **18** is a chamber **12** which forms a conduit **26** by means of a rigid inner wall **22**. Inner wall **22** is held in place by the support members **14** and **24**. Contained within conduit **26** and free to circulate therein is a ferromagnetic fluid which characteristically comprises a colloidal suspension of submicron size ferrite particles in a carrier fluid such as kerosene with a disbursing agent added to prevent flocculation. When a magnetic field is applied to such a fluid, a body force is developed within it which changes its velocity and momentum. For a more complete discussion of such fluids, reference is made to an article by R. E. Rosenweig, entitled "Magnetic Fluids," which appeared at pages 48–56 in the July 1966 issue of *International Science and Technology*, published by Conover Mast Publications in New York.

The actuating force for the ferromagnetic fluid is provided by a plurality of conducting wires **30**, **32**, **34**, and **36** which are in the form of conducting loops of wire located circumferentially to flexible tube **18**. The groups of conducting loops as shown in FIG. **1** are illustrative of only one of a number of possible configurations that would be in accordance with the teachings of the present invention. Loops **30** and **32** are shown adjacent to inner wall **22** and in alternating position from loops **34** and **36** which are shown immediately adjacent to flexible tube **18**. This represents a hybrid embodiment of the present invention in which flexible tube **18** would both expand and collapse along its length to provide the pumping action, as will be explained more fully hereinafter. At this point it is enough to understand that the peristaltic pump as shown in FIG. **1** would work equally well if all the groups of conducting loops were confined to inner wall **22** or, alternatively, they could all be located immediately adjacent to flexible tube **18**. In the former case, the pumping action would be solely provided by the expansion of flexible tube **18**, while in the latter case it would be provided solely by the constriction of flexible